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NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
PATUXENT RIVER, MARYLAND

TECHNICAL REPORT

REPORT NO: NAWCADPAX/TR-2001/140

REVISED ANTHROPOMETRIC RESTRICTIONS FOR U.S. NAVY AND MARINE CORPS ROTARY WING, TRAINER, AND C-130 AIRCRAFT AND U.S. COAST GUARD HH-65 AND HU-25

by

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Jennifer Crawford
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RELEASED BY:

21 Sep 2001

RON CRESCINI / CODE 4.6.4 / DATE
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REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188

1. REPORT DATE 21 September 2001	2. REPORT TYPE Technical Report	3. DATES COVERED

4. TITLE AND SUBTITLE Revised Anthropometric Restrictions for U.S. Navy and Marine Corps Rotary Wing, Trainer, and C-130 Aircraft and U.S. Coast Guard HH-65 and HU-25	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) Heather Tucker, Jennifer Crawford, Lori Brattin William Reason, Greg Kennedy	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Air Warfare Center Aircraft Division 22347 Cedar Point Road, Unit #6 Patuxent River, Maryland 20670-1161	8. PERFORMING ORGANIZATION REPORT NUMBER NAWCADPAX/TR-2001/140
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Naval Air Systems Command 47123 Buse Road Unit IPT Patuxent River, Maryland 20670-1547	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release, distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

NAVAIRSYSCOM (PMA-202) tasked NAWCAD Patuxent River, Maryland, (AIR-4.6) to perform a baseline accommodation assessment of existing U.S. Navy (USN) and U.S. Marine Corps (USMC) rotary wing aircraft and their respective trainer aircraft and establish anthropometric restriction codes (ARC's) as appropriate. The assessment also determined the estimated percentage of future candidate aviators suitable for flight duty in a particular aircraft with respect to their measured anthropometric characteristics. The percents reported were based on the population data set used to provide seven test cases cited in the Joint Services Specification Guidance 2010-3. The methods used in the assessment were different than procedures historically used to determine USN and USMC aviator suitability and to verify cockpit design. A multivariate statistical approach was employed and served as the basis for determining the safe accommodation envelopes for each platform/crew station. Revised ARC's are presented and the respective percents accommodated are summarized.

15. SUBJECT TERMS

Anthropometric Restriction Codes (ARC's), Rotary Wing Aircraft, Trainer Aircraft, C-130 Aircraft
HH-65 Aircraft, HU-25 Aircraft, Aircrew Accommodation, Human Factors

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON Heather Tucker
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (include area code)
Unclassified	Unclassified	Unclassified	SAR	31	(301) 342-9282

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18

SUMMARY

NAVAIRSYSCOM (PMA-202) tasked NAWCAD Patuxent River, Maryland, (AIR-4.6) to perform a baseline accommodation assessment of existing U.S. Navy (USN) and U.S. Marine Corps (USMC) rotary wing aircraft and their respective trainer aircraft and establish anthropometric restriction codes (ARC's) as appropriate. The assessment also determined the estimated percentage of future candidate aviators suitable for flight duty in a particular aircraft with respect to their measured anthropometric characteristics. The percents reported were based on the population data set used to provide seven test cases cited in the Joint Services Specification Guidance 2010-3. The methods used in the assessment were different than procedures historically used to determine USN and USMC aviator suitability and to verify cockpit design. A multivariate statistical approach was employed and served as the basis for determining the safe accommodation envelopes for each platform/crew station. Revised ARC's are presented and the respective percents accommodated are summarized.

Limitations to accommodating an increased percentage of smaller dimension/weight personnel in USN and USMC rotary wing aircraft were noted. These limitations included meeting the structural design criteria of the seat, ensuring a nude body weight minimum necessary for center of gravity concerns, and achieving external field of view simultaneously while maintaining a capability to reach and operate primary flight controls or other immediate-action emergency controls with a locked harness. Additionally, limitations to accommodating an increased percentage of larger dimension personnel in USN and USMC rotary wing aircraft were noted. These limitations included meeting the structural design criteria of the seat and ensuring sufficient clearances within the crew station. The ARC's and resultant percent accommodated presented within this report do not address additional accommodation limitations due to the effects of flying aggressive flight profiles or based on individual aircrew strength.

Contents

ACKNOWLEDGEMENTS

The authors acknowledge the contributions of the following personnel to the completion of this evaluation:

Messrs. Brad Johnson and Mike Jaffee, and Ms. Holli Galletti (NAVAIRSYSCOM) for their outstanding leadership, guidance, and encouragement of the Aircrew Accommodation Expansion Program (AAEP) Team during their tenure as Program Managers.

Mr. Brian Hall (NAVAIRSYSCOM) for his outstanding leadership, guidance, and encouragement of the AAEP Team as the current Program Manager.

Mr. Art Weaver (RED, Inc.) for his corporate knowledge of human factors and applicable Military Standards.

Ms. Elizabeth Walter and Mr. Drew Kirkpatrick (ARINC) for subject coordination, aircraft coordination, and support plan development.

Mr. Bruce Fleming (BFCS, Inc. and SEMCOR) for researching and providing cockpit layouts, cockpit geometry data, and aircraft coordinate system reference points.

Mr. Michael Raphael (Direct Dimensions, Inc.) for advanced training and support with the use of the FaroArm™.

INTRODUCTION

BACKGROUND

1. Anthropometric restriction codes (ARC’s) contained in references 1 and 2 are outdated, undocumented, and require the use of a fit check process that is subjective. Recent reassignments of aviators within the U.S. Navy (USN)/U.S. Marine Corps (USMC) have highlighted an area where small improvements to a simple nonclinical test could save operational dollars, and potentially reduce mishaps where ill-suited anthropometrics have been cited as causal or contributory factors. These issues were revealed during the course of the NAVAIRSYSCOM (PMA-202) Aircrew Accommodation Expansion Program where NAWCAD Patuxent River, Maryland, (AIR-4.6) was tasked to perform a baseline accommodation assessment of in-service USN/USMC aircraft (reference 3). The methods used in the program approach were different than procedures historically used to determine USN/USMC aviator suitability and to verify cockpit design. A multivariate statistical approach was employed and served as the basis for determining the safe accommodation envelopes for each platform/crew station. The revised ARC’s and resultant percent accommodated within this report account for the following:

a. Estimated next generation of aviators (reference 4) and aircraft design specifications (reference 5).

b. Location of the seat with respect to the interacting variables that affect the appropriate seat location.

c. Statistical precision of the predicted accommodation envelope.

d. Operational use of the codes and pipeline relational charting.

e. Potential cost avoidance associated with assigning aviators to their suitable aircraft up front and early via the proposed ARC system presented.

These revised ARC’s and percent accommodated are established from the aircrew accommodation analyses conducted under reference 3. These revised ARC’s define the acceptable range of aircrew anthropometric dimensions that must be satisfied to achieve safety of flight and mission effectiveness.

PURPOSE

2. The purpose of this report is to provide revised ARC’s for USN/USMC rotary wing, trainer, and C-130 aircraft, and U.S. Coast Guard HH-65 and HU-25 aircraft, and to provide an estimated percentage of a given population that is accommodated in each aircraft.

SCOPE OF TESTS

3. Evaluations of aircrew anthropometric accommodation in the T-34C, TH-57C, AH-1W, SH-60B, UH-1N, C-130T, and C-130J aircraft were conducted at NAS Patuxent River, Maryland. The TC-12 evaluation was conducted at NAS Corpus Christi, Texas. The CH-46 and CH-53E evaluations were conducted at MCB Quantico, Virginia. The MV-22 evaluation was conducted at MCAS New River, North Carolina. The HH-65 and HU-25 evaluations were conducted at Elizabeth City, North Carolina. The T-6A aircraft was assessed based on available data and dialogue with the U.S. Air Force. Additional Man-Machine Integration Laboratory (MMIL) work augmented the on-aircraft data collection where data were unable to be obtained appropriately. Each of the evaluations typically required 30 hr of ground tests conducted over a 3-day period. Aircrew accommodation data were collected in both crew stations for each aircraft. In all measured test trials, subjects were attired in the full complement of summer flight gear as specified for each aircraft in reference 6. Evaluation of aircrew anthropometric accommodation included the following five functional parameters:

a. External field of view (FOV) (ability to obtain design eye point (DEP)).

b. Reach to controls (ability to operate critical flight and emergency controls with a locked harness).

c. Reach to pedals (ability to gain adequate rudder pedal authority).

d. Leg clearance (ability to have lower leg clearance to the main instrument panel).

e. Overhead clearance (ability to have head clearance to any overhead obstructions).

4. The ARC’s presented within this report do not address these additional accommodation issues: the effects of aggressive flight profiles, individual aircrew strength, or nonflight/enlisted crew stations.

5. Although the methods employed in this accommodation study differ from those used during aircraft design and development, the results herein reported do not necessarily imply any deficiency with respect to specification compliance by the airframe manufacturer, seat contractors, or the procuring agency.

METHOD

GENERAL

6. A pool of 10 (on-aircraft evaluation) to 30 (MMIL evaluation) test subjects, representing the range of candidate aviator anthropometric characteristics, as seen in figure 1 and reference 4, were measured in accordance with the methods established by reference 7. Crew station geometry and subject accommodation data were collected using the procedures outlined in reference 8.

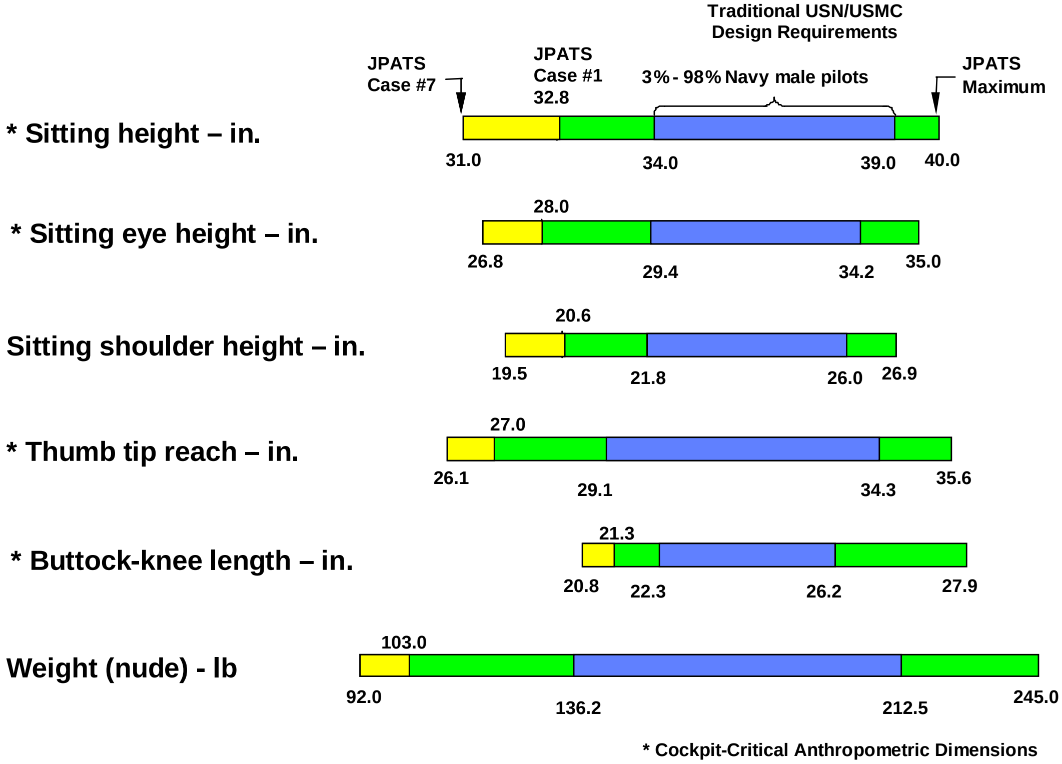

Figure 1: Past and Present USN Aircraft Accommodation Specification Criteria

DATA COLLECTION

7. The initial crew station geometry measurements were collected using the FaroArm™, an 8-ft long, 6 degree of freedom, articulating arm with an accuracy of 0.004 in. The FaroArm™ is a portable coordinate measurement machine that takes data such as points, lines, and planes in a three-dimensional coordinate system, and places these features in an AutoCAD® drawing via AnthroCAM™ software. The crew station geometry measurements were made to align the FaroArm™ with the aircraft coordinate reference system, when available, and to record the locations of flight control and cockpit control test points, clearance obstructions, and the adjustment ranges of the seat and rudder pedals.

8. After crew station geometry collection, a subject accommodation evaluation was then performed, placing each subject at four to five locations along the full range of available seat positions. Specific measurement criteria in this evaluation were as follows:

a. Clearance measurements were taken between the top of the helmet (while the subjects' heads were stationary and upright) and the closest overhead surface.

b. Lower leg clearance distances were measured between the lowest edge of the main instrument panel and the subjects' shins while their feet were resting on the pedals in a normal flight position.

c. Reach distances to pedals were measured between the full aft position of the pedals and the furthest forward pedal location where full rudder pedal authority was achieved.

d. The ability of each subject to reach and operate the control stick and other essential or emergency controls in each crew station was evaluated. Reach was evaluated in the zone 2 condition (shoulder harness locked with maximal stretching of arm and shoulder).

e. External FOV was evaluated by determining whether each subject could establish a horizontal vision line through the DEP.

DATA ANALYSIS

9. Data generated by the FaroArm™ evaluation were organized into a Microsoft Excel® worksheet. Data were reduced into accommodation prediction equations through multiple regression analyses. The independent variables were the subjects' anthropometric measurements and the seat adjustment heights. The dependent variables were miss/over reach or clearance distances.

10. These prediction equations were then employed to determine the accommodation envelope for each anthropometric dimension in each aircraft. The equations exhibit coefficients of determination (R^2) of 0.8 or greater. The standard error associated with each regression equation was generally less than 0.5 in. except for those involving the prediction of arm reach capability where the goal was generally to achieve 1.0 in. or less standard error.

11. Each aircraft and crew station had its own unique set of univariate thresholds established from the regression analyses.

12. The analysis was based on an expanded range of anthropometric measurements reflecting an anticipated DoD population defined in references 4 and 5. The critical cockpit anthropometric characteristics of this anticipated DoD population are covered in table 1, which defines USN/USMC rotary wing aircraft ARC's in terms of 13 proposed intervals around 4 significant cockpit-critical anthropometric dimensions, as noted by the "*****" in figure 1. AIR-4.6 recommends expanding the overall anthropometric restriction coding system to match the other guidance available to airframe vendors as design criteria. AIR-4.6 also recommends the critical minimums and maximums (codes 0 and 12) be restricted as presented in table 1.

Table 1: Proposed USN/USMC Personal Anthropometric Codes

Code	Nude Body Weight (lb)	Sitting Eye Height (in.)	Thumb Tip Reach (in.)	Buttock-Knee Length (in.)	Sitting Height (in.)
0	<100 [1]	<26	<26	<20.4	<31
1	100 [2] -116.5	26-26.4	26-26.4	20.5-20.9	31-31.9
2	116.6-136 [3]	26.5-26.9	26.5-26.9	21-21.9	32-32.9
3	136.1-140 [4]	27-27.4	27-27.4	22-22.4 [15]	33-33.9
4	140.1-155	27.5-27.9	27.5-27.9	22.5-25.4 [16, 17]	34-34.4 [20, 21]
5	155.1-170	28-28.4	28-28.4	25.5-25.9 [18]	34.5-37.4 [22]
6	170.1-185	28.5-28.9	28.5-28.9	26-26.4 [19]	37.5-38.4 [23]
7	185.1-195	29-29.4 [9]	29-29.4 [12, 13]	26.5-26.9	38.5-38.9
8	195.1-204 [5]	29.5-29.9 [10]	29.5-29.9	27-27.4	39-39.4 [24]
9	204.1-213 [6]	30-30.4	30-30.4	27.5-27.9	39.5-39.9
10	213.1-235 [7]	30.5-30.9	30.5-30.9	28-28.4	40-40.4
11	235.1-245 [8]	31-31.4	31-31.4 [14]	28.5-28.9	40.5-40.9
12	>245	>31.5 [11]	>31.5	>29	>41

Nude Body Weight
1. Below MANMED lower limit (reference 9)
2. Joint Primary Aircraft Trainer System (JPATS) seat lower limit (reference 5)
3. 3rd = 136 (reference 10)
4. 5th = 140 (reference 10)
5. 95th = 204 (reference 10)
6. 98th = 213 (reference 10)
7. MANMED upper limit (reference 9)
8. JPATS seat upper limit (reference 5)

Sitting Eye Height
9. 3rd = 29.41 (reference 10)
10. 5th = 29.70 (reference 10)
11. 50th = 31.52 (reference 10)

Thumb Tip Reach
12. 3rd = 29.07 (reference 10)
13. 5th = 29.33 (reference 10)
14. 50th = 31.40 (reference 10)

Buttock-Knee Length
15. 3rd = 22.28 (reference 10)
16. 5th = 22.50 (reference 10)
17. 50th = 24.06 (reference 10)
18. 95th = 25.80 (reference 10)
19. 98th = 26.24 (reference 10)

Sitting Height
20. 3rd = 33.96 (reference 10)
21. 5th = 34.24 (reference 10)
22. 50th = 36.27 (reference 10)
23. 95th = 38.36 (reference 10)
24. 98th = 38.95 (reference 10)

13. The proposed revised coding interval system, table 1, was used in conjunction with the resultant univariate analyses to generate the updated and revised anthropometric restriction coding for USN/USMC rotary wing aircraft. The ARC's are presented in the appendix.

14. The final ARC's were entered into a software package, Automated Anthropometric Evaluation Program, which delivers the compatibility between aircrew and aircraft.

15. A percentage of a given population was determined by dividing the number of successful accommodation values by the total number of individuals in the population data set (reference 4).

RESULTS

GENERAL

16. The results of these tests indicate recommended minimum pilot sitting eye height in USN/USMC rotary wing aircraft generally ranges from 27.5 to 28.5 in. These minimum sitting eye heights are based on external visibility requirements listed in reference 11. Individuals at or near the minimum sitting eye height will require a seat location near full up, or approximately 2 in. higher than the neutral seat reference position, to obtain a horizontal line of vision through the DEP. AIR-4.6 recommends use of the sitting eye height measurement as an anthropometric screening criterion for candidate aviators.

17. The results of these tests indicate a recommended minimum pilot thumb tip reach of 27.0 to 28.5 in. for the operation of primary flight controls and immediate action emergency controls. As a two-axis seat moves upward and aft, the occupant is pulled away from the primary flight controls, instrument panel controls, and center console controls, but is placed closer to the DEP and overhead controls. Therefore, there is a strong relationship between obtaining the requisite downward, over the nose, FOV capability and maintaining full reach capability to all controls.

18. The results of these tests indicate that a buttock-knee length of greater than 21.0 in. is recommended to gain adequate rudder pedal authority. In general, these measurements indicate that a buttock-knee length of less than 28.5 in. will safely clear the main instrument panel.

19. The results of these tests indicate recommended maximum sitting height in USN/USMC rotary wing aircraft generally ranges from 39.9 to 40.9 in. to ensure clearance to any overhead obstructions.

AIRCRAFT SPECIFIC

T-6A

20. The results of these analyses indicate that 96.2% of the population contained in the reference 4 population data base were accommodated in both crew stations of the T-6A trainer aircraft.

T-34C

21. The results of these analyses indicate that 84.5% of the population contained in the reference 4 population data base were accommodated in the T-34C trainer aircraft forward crew station.

22. The results of these analyses indicate that 91.0% of the population contained in the reference 4 population data base were accommodated in the T-34C trainer aircraft aft crew station.

TH-57C

23. The results of these analyses indicate that 88.4% of the population contained in the reference 4 population data base were accommodated in both crew stations of the TH-57C trainer aircraft.

TC-12

24. The results of these analyses indicate that 90.8% of the population contained in the reference 4 population data base were accommodated in both crew stations of the TC-12 trainer aircraft.

AH-1W

25. The results of these analyses indicate that 89.8% of the population contained in the reference 4 population data base were accommodated in the AH-1W aircraft forward crew station. If stipulating that a nude body weight minimum of 140 lb is required for center of gravity (CG) concerns, then 64.2% of the population contained in the reference 4 population data base were accommodated in the AH-1W aircraft forward crew station.

26. The results of these analyses indicate that 90.0% of the population contained in the reference 4 population data base were accommodated in the AH-1W aft crew station.

CH-46

27. The results of these analyses indicate that 83.1% of the population contained in the reference 4 population data base were accommodated in both crew stations of the CH-46 aircraft.

CH-53E

28. The results of these analyses indicate that 83.1% of the population contained in the reference 4 population data base were accommodated in both crew stations of the CH-53E aircraft.

SH-60B

29. The results of these analyses indicate that 67.9% of the population contained in the reference 4 population data base were accommodated in both crew stations of the SH-60B aircraft.

UH-1N

30. The results of these analyses indicate that 88.3% of the population contained in the reference 4 population data base were accommodated in both crew stations of the UH-1N aircraft.

MV-22

31. The results of these analyses indicate that 88.9% of the population contained in the reference 4 population data base were accommodated in both crew stations of the MV-22 aircraft.

HH-65

32. The results of these analyses indicate that 74.8% of the population contained in the reference 4 population data base were accommodated in both crew stations of the HH-65 aircraft.

C-130T

33. The results of these analyses indicate that 88.7% of the population contained in the reference 4 population data base were accommodated in both crew stations of the C-130T aircraft.

C-130J

34. The results of these analyses indicate that 88.7% of the population contained in the reference 4 population data base were accommodated in both crew stations of the C-130J aircraft.

HU-25

35. The results of these analyses indicate that 89.7% of the population contained in the reference 4 population data base were accommodated in the HU-25 aircraft right crew station.

36. The results of these analyses indicate that 86.3% of the population contained in the reference 4 population data base were accommodated in the HU-25 aircraft left crew station.

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DISCUSSION

GENERAL

37. Aviator anthropometric compatibility with cockpit geometry is a safety of flight issue. OPNAV policy guidance (reference 12), direction, and tasking to lower echelon commands is essential to ensure that aviation flight duty requirements for safety of flight are assured and maintained. Reference 12, however, was cancelled and only recently reissued on 1 November 1999 (reference 13). Incorporation of the revised ARC's presented in the appendix in future updates to references 1 and 2 will enhance the ability to safely assign aviators to rotary wing aircraft pipelines, preserve flight safety, maintain mission effectiveness, and avoid downstream costs associated with reassignment processing due to cockpit incompatibility. AIR-4.6 recommends that references 1, 2, and 9 be updated to display anthropometric thresholds as presented in table 1. AIR-4.6 also recommends that references 1 and 2 be updated to display ARC's as presented in the appendix.

38. Some of these aircraft land aboard aircraft carriers. Therefore, the guidance contained in reference 11 served as an operational/specification requirement. Locked harness reach tasks are not well defined by a requisite and recurring operational task. AIR-4.6 evaluates cockpit accommodation with a locked harness (reference 8) to represent the worst case scenario because of the repeatability and consistency of measurement. The NATOPS is not clear with respect to harness locking conditions throughout all phases of flight.

INDIVIDUAL BODY WEIGHT

39. For most rotary wing seats designed through the present, the minimum and maximum nude weight of aircrew is related to the structural limits of the seat, either based on the 5th through 95th or 5th through 98th percentile weights listed in references 14 and 15. The intent was satisfying a range of 90% and 95% of a population, respectively. Those seats with a nonadjustable energy absorber are optimized for the 50th percentile male weight; lighter occupants outside the design point of the seat are not restricted from flight, but are at an increased risk for spinal injury in the event of an impact.

BUTTOCK-KNEE LENGTH VERSUS BUTTOCK-LEG LENGTH

40. The buttock-knee length measurement is used to predict shin clearance and can reasonably be used to establish adequate rudder pedal authority. In a test performed at the Naval Operational Medicine Institute in June 1999, it was determined that the buttock-knee length measurement comprised 57% of the overall leg length. This percentage was also compared to the reference 4 data set where the actual measurement process of buttock-leg length was slightly different. Nonetheless, it was consistent for the vast majority of cases examined. AIR-4.6 recommends elimination of the buttock-leg length measurement of candidate aviators as an anthropometric screening criterion as the buttock-knee length is a very strong predictor of overall leg length.

CURRENT U.S. NAVY/MARINE CORPS POPULATION

41. The reference population does not correspond with current operational USN/USMC realities. According to reference 16, the projected population was designed to match the racial mix of the 1992 Department of Education college graduates who were 22 years of age or older and within the USN/U.S. Air Force height and weight standards. The current proportion of females in USN/USMC aviation billets is 4% of the USN/USMC flying population (reference 17). The reference 4 population data base proportion is at 40% (848 females to 1,294 males). Additionally, the reference 4 population data base exhibits no personnel possessing body weights greater than 235 lb. During an AIR-4.6 evaluation in March 1998, several of the student naval aviators and instructors were weighed. Of the 33 aviators weighed, 8 (24%) were in excess of 213 lb and 3 (9%) were above 235. AIR-4.6 recommends the reference population be adjusted on a sliding scale to represent current and projected operational populations and validated in terms of future operational projections as soon as practicable.

AIRCRAFT SPECIFIC

T-6A

42. Both crew stations of the T-6A trainer aircraft were quite accommodating based on the reference 4 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the maximum buttock-knee length allowable for knee clearance to the main instrument panel.

T-34C

43. Both crew stations of the T-34C trainer aircraft were quite accommodating based on the reference 4 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

TH-57C

44. Both crew stations of the TH-57C trainer aircraft were quite accommodating based on the reference 4 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the maximum sitting height allowable for overhead clearance.

TC-12

45. Both crew stations of the TC-12 trainer aircraft were quite accommodating based on the reference 4 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

AH-1W

46. Both crew stations of the AH-1W aircraft were quite accommodating based on the reference 4 population data base. If stipulating that a nude body weight minimum of 140 lb is required for CG concerns, then the forward crew station was fairly accommodating based on the reference 4 data base. Limitations to achieving a larger percent accommodated in the forward crew station were noted in terms of the maximum sitting height allowable for overhead clearance, the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness, and the minimum nude body weight necessary for CG concerns. Limitations to achieving a larger percent accommodated in the aft crew station were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

CH-46

47. Both crew stations of the CH-46 aircraft were quite accommodating based on the reference 4 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

CH-53E

48. Both crew stations of the CH-53E aircraft were quite accommodating based on the reference 4 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

SH-60B

49. Both crew stations of the SH-60B aircraft were fairly accommodating based on the reference 4 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness and the ability to gain adequate rudder pedal authority.

UH-1N

50. Both crew stations of the UH-1N aircraft were quite accommodating based on the reference 4 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

MV-22

51. Both crew stations of the MV-22 aircraft were quite accommodating based on the reference 4 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

HH-65

52. Both crew stations of the HH-65 aircraft were fairly accommodating based on the reference 4 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

C-130T

53. Both crew stations of the C-130T aircraft were quite accommodating based on the reference 4 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

C-130J

54. Both crew stations of the C-130J aircraft were quite accommodating based on the reference 4 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

HU-25

55. Both crew stations of the HU-25 aircraft were quite accommodating based on the reference 4 population data base. Limitations to achieving a larger percent accommodated in both crew stations were noted in terms of the ability to maintain external FOV while simultaneously reaching to the primary flight controls with a locked harness.

CONCLUSIONS

GENERAL

56. Minimum pilot sitting eye height in USN/USMC rotary wing aircraft generally ranges from 27.5 to 28.5 in. (paragraph 16).

57. Minimum pilot thumb tip reach ranges from 27.0 to 28.5 in. for the operation of primary flight controls and immediate action emergency controls (paragraph 17).

58. A buttock-knee length between 21.0 and 28.5 in. will generally ensure accommodation while allowing safe operation under normal and emergency conditions (paragraph 18).

59. Maximum sitting height generally ranges from 39.9 to 40.9 in. to ensure clearance to any overhead obstructions (paragraph 19).

AIRCRAFT SPECIFIC

T-6A

60. Both crew stations of the T-6A trainer aircraft accommodate 96.2% of the population in the reference 4 population data base (paragraph 20).

T-34C

61. The forward crew station of the T-34C aircraft accommodates 84.5% of the population in the reference 4 population data base. The aft crew station accommodates 91.0% of the population (paragraphs 21 and 22).

TH-57C

62. Both crew stations of the TH-57C trainer aircraft accommodate 88.4% of the population in the reference 4 population data base (paragraph 23).

TC-12

63. Both crew stations of the TC-12 trainer aircraft accommodate 90.8% of the population in the reference 4 population data base (paragraph 24).

AH-1W

64. The forward crew station of the AH-1W aircraft accommodates 89.8% of the population in the reference 4 population data base. If stipulating that a minimum nude body weight of 140 lb is required for CG concerns, the forward crew station of the AH-1W aircraft accommodates 64.2% of the population in the reference 4 population data base. The aft crew station accommodates 90.0% of the population (paragraphs 25 and 26).

CH-46

65. Both crew stations of the CH-46 aircraft accommodate 83.1% of the population in the reference 4 population data base (paragraph 27).

CH-53E

66. Both crew stations of the CH-53E aircraft accommodate 83.1% of the population in the reference 4 population data base (paragraph 28).

SH-60B

67. Both crew stations of the SH-60B aircraft accommodate 67.9% of the population in the reference 4 population data base (paragraph 29).

UH-1N

68. Both crew stations of the UH-1N aircraft accommodate 88.3% of the population in the reference 4 population data base (paragraph 30).

MV-22

69. Both crew stations of the MV-22 aircraft accommodate 88.9% of the population in the reference 4 population data base (paragraph 31).

HH-65

70. Both crew stations of the HH-65 aircraft accommodate 74.8% of the population in the reference 4 population data base (paragraph 32).

C-130T

71. Both crew stations of the C-130T aircraft accommodate 88.7% of the population in the reference 4 population data base (paragraph 33).

C-130J

72. Both crew stations of the C-130J aircraft accommodate 88.7% of the population in the reference 4 population data base (paragraph 34).

HU-25

73. The right crew station of the HU-25 aircraft accommodates 89.7% of the population in the reference 4 population data base. The left crew station accommodates 86.3% of the population (paragraphs 35 and 36).

RECOMMENDATIONS

74. Expand the overall anthropometric restriction coding system to match the other guidance available to airframe vendors as design criteria (paragraph 12).

75. Restrict the critical minimums and maximums (codes 0 and 12) as presented in table 1 (paragraph 12).

76. Use the sitting eye height measurement as an anthropometric screening criterion for candidate aviators (paragraph 16).

77. Update references 1, 2, and 9 to display anthropometric thresholds as presented in table 1 (paragraph 37).

78. Update references 1 and 2 to display ARC's as presented in the appendix (paragraph 37).

79. Eliminate the buttock-leg length measurement of candidate aviators as an anthropometric screening criterion as the buttock-knee length is a very strong predictor of overall leg length (paragraph 40).

80. Adjust the reference population on a sliding scale to represent current and projected operational populations and validate in terms of future operational projections as soon as practicable (paragraph 41).

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APPENDIX
REVISED ANTHROPOMETRIC RESTRICTION CODES

This appendix was prepared for insertion to future releases of the NAVAIR 3710.9 and CNATRA 13520.1 series instructions. It is presented in chart format for ready viewing of pipeline relationships.

It was designed to be used by personnel responsible for assigning candidate USN/USMC aviators to appropriate pipelines.

It uses the coding intervals as established in table 1, and indicates all the specification thresholds with respect to how these aircraft and future aircraft were designed. Values highlighted in pink, green, or blue above a particular coding column indicate the exact values of the 3^{rd} and 5^{th} (pink), 50^{th} (green), and 95^{th} and 98^{th} (blue) percentiles from a 1964 USN aviator data population, reference 10.

The current instructions make use of four codes: sitting height, thumb tip reach, buttock-knee length, and buttock-leg length. The codes are not evaluated in terms of their relationship to one another.

This new proposed ARC chart accounts for eight parameters of concern, including a first pass on five criteria (sitting eye height, thumb tip reach, buttock-knee length, sitting height, and weight). To potentially be compatible with the aircraft, an individual should have each dimension within one of the green cells and meet the weight criteria listed. Then the assessment of aviator suitability should evaluate three critical relationships:

a. sitting eye height and thumb tip reach (ability to attain DEP and reach to controls)

b. sitting eye height and buttock-knee length (ability to attain DEP and operate foot controls)

c. sitting height and buttock-knee length (ability to attain overhead and knee clearances)

In order to calculate the sitting eye height measurement for an individual, subtract 4.8 in. from the sitting height for males, or subtract 4.5 in. from the sitting height for females.

The ARC's were determined from AIR-4.6 univariate results that indicated thresholds required for all dimensions at various seat locations. The resultant minimums were evaluated concurrently to determine the combined scores required for the critical relationships described above.

NAWCADPAX/TR-2001/140

Rotary Wing, Trainer, C-130, and USCG HH-65 and HU-25 Aircraft Anthropometric Restriction Codes

Rotary Wing, Trainer, C-130, and USCG HH-65 and HU-25 ARC's

Sitting Eye Height (SEH) in Inches

Code	0	1	2	3	4	5	6	7	8	9	10	11	12
								29.41	29.7				31.52
Inches	<26	26-26.4	26.5-26.9	27-27.4	27.5-27.9	28-28.4	28.5-28.9	29-29.4	29.5-29.9	30-30.4	30.5-30.9	31-31.4	>31.5

Thumb Tip Reach (TTR) in Inches

Code	0	1	2	3	4	5	6	7	8	9	10	11	12
								29.07 29.33				31.4	
Inches	<26	26-26.4	26.5-26.9	27-27.4	27.5-27.9	28-28.4	28.5-28.9	29-29.4	29.5-29.9	30-30.4	30.5-30.9	31-31.4	>31.5

Buttock Knee Length (BKL) in Inches

Code	0	1	2	3	4	5	6	7	8	9	10	11	12
				22.26	22.5 24.06	25.8	26.24						
Inches	<20.4	20.5-20.9	21-21.9	22-22.4	22.5-25.4	25.5-25.9	26-26.4	26.5-26.9	27-27.4	27.5-27.9	28-28.4	28.5-28.9	>29

Sitting Height (SH) in Inches

Code	0	1	2	3	4	5	6	7	8	9	10	11	12
					33.96 34.24	36.27		38.38	38.95				
Inches	<31	31-31.9	32-32.9	33-33.9	34-34.4	34.5-37.4	37.5-38.4	38.5-38.9	39-39.4	39.5-39.9	40-40.4	40.5-40.9	>41

Aircraft	Crewstation	SEH+TTR	SEH+BKL	SH+BKL	Nude Body Weight in pounds Minimum	Nude Body Weight in pounds Maximum
T-6A	Both	≥6	5-21	4-20		
T-34	Forward	≥10	5-21	4-20		
T-34	Aft			3-20		
TH-57	Both	≥10	6-21	4-17	103	225
TC-12	Both	≥7	6-23	5-22		
AH-1W	Forward	≥10	7-23	4-20	103 (140)	220
AH-1W	Aft	≥10	7-23	4-22	103	220
CH-46	Both	≥12	8-22	5-21	103	225
CH-53	Both	≥12	8-22	5-21	103	225
SH-60B	Both	≥15	9-23	6-22	103	212
UH-1N	Both	≥10	6-23	4-22	103	212
MV-22	Both	≥10	6-21	4-20	107	323
HH-65	Both	≥14	8-23	5-22		
C-130T	Both	≥10	8-23	5-22		
C-130J	Both	≥10	7-23	5-22		
HU-25	Right	≥9	8-23	5-22		
HU-25	Left	≥11	8-23	5-22		

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